

# **Development and Testing of Carbon-Carbon Nozzle Extensions for Upper Stage Liquid Rocket Engines**

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Carbon-carbon (C-C) composite nozzle extensions are of interest for use on a variety of launch vehicle upper stage engines and in-space propulsion systems. The C-C nozzle extension technology and test capabilities being developed are intended to support National Aeronautics and Space Administration (NASA) and Department of Defense (DOD) requirements, as well as those of the broader Commercial Space industry. For NASA, C-C nozzle extension technology development primarily supports the NASA Space Launch System (SLS) and NASA's Commercial Space partners.

Marshall Space Flight Center (MSFC) efforts are aimed at both (a) further developing the technology and databases needed to enable the use of composite nozzle extensions on cryogenic upper stage engines, and (b) developing and demonstrating low-cost capabilities for testing and qualifying composite nozzle extensions. Recent, on-going, and potential future work supporting NASA, DOD, and Commercial Space needs will be discussed. Information to be presented will include (a) recent and on-going mechanical, thermal, and hot-fire testing, as well as (b) potential future efforts to further develop and qualify domestic C-C nozzle extension solutions for the various upper stage engines under development.